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Riparian Buffers for Runoff Control and Sensitive Species Habitat on U.S. Army Corps of Engineers Lake and Reservoir Projects

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PURPOSE: The purpose of this document is to provide a conceptual framework for a field demonstration of multi-functional, vegetated riparian buffers, which would be placed on reservoir shorelines and riverine tributaries to lakes and reservoirs operated by the United States (U.S.) Army Corps of Engineers (USACE). Riparian buffers will not only provide traditional control of sediment, nutrients, and other chemicals in runoff entering the reservoir, but also potentially provide habitat for federally listed and "at-risk" birds and other sensitive species. The study focuses on applications in the southwestern U.S., which is managed by the USACE South Pacific Division (SPD).

BACKGROUND: Riparian areas are transitional habitats that bridge terrestrial areas with aquatic sites, including rivers, lakes, or reservoirs (Fischer and Fischenich 2000, Figure 1). Riparian areas are typically characterized by relatively thick, herbaceous, and woody vegetation, including a relative abundance of riparian trees. Vegetation growth is stimulated by the abundance of water, and the availability of nutrients from both upland runoff and occasional overbank flooding. Although riparian areas comprise a relatively small part of most landscapes (usually <5%), they provide diverse habitat for wildlife species, including nesting areas for up to 50 percent of all North American bird species (Fischer and Fischenich 2000, Kirkpatrick et al. 2009). Riparian areas are occasionally classified by their intended function. For example, riparian buffer strips are relatively thin strips of vegetation with a primary objective of protecting or improving water quality and protecting erosion, whereas riparian corridors tend to be much wider vegetated areas that are designed to promote both habitat and movement of wildlife across the landscape (Fischer and Fischenich 2000). Riparian area rehabilitation designs should be developed based on these and other objectives (Fischenich 2006).

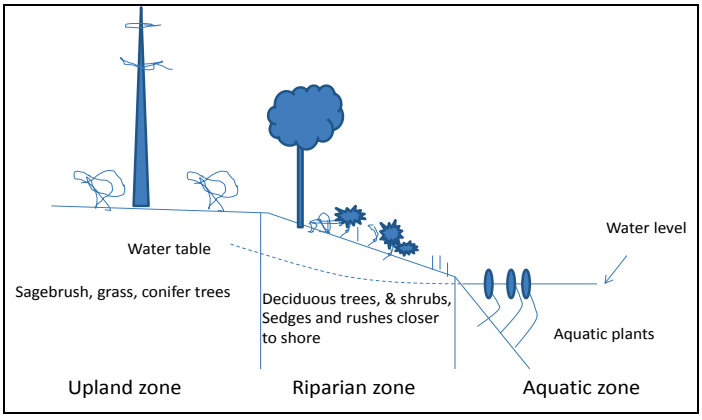

Figure 1. Conceptual Drawing of Riparian Zone.

Benefits of Riparian Areas to USACE. Riparian buffers can provide significant benefits to USACE including:

- ***Protection of water quality*** – Riparian buffers have long been recognized for their beneficial aspects in protecting water bodies from runoff. Riparian buffers protect and improve water quality by reducing or eliminating non-point source pollution and filtering out sediment, nutrients (which can stimulate unwanted algal growth), and harmful chemicals (Fry et al. 1994, Fischer et al. 1999, Mankin et al. 2007, Mayer 2007, Wegner 1999). Riparian buffers are a best management practice (BMP) for controlling nitrogen in streams, wetlands, and other water bodies (Mayer et al. 2006).

- ***Temperature control*** - Well-maintained riparian areas along streams and lakes can provide shade to reduce solar heating and control stream temperatures, thereby resulting in measurably cooler water temperatures (Lowry et al. 2008). Increased water temperatures can negatively affect many desirable fish species, including salmon and trout.

- ***Reduction of Shoreline Erosion*** – Riparian areas reduce shoreline erosion from wave action by providing rooted vegetation that holds soil/sediment in place (Fry et al. 1994). Shoreline erosion is a long established problem at USACE reservoir projects. Allen and Wade (1991) estimated that more than 10,000 miles of USACE reservoir shorelines exhibit moderate to severe erosion problems.

- ***Recreational benefits*** – USACE operates approximately 12 million acres of recreational public lands and water in the U.S. (USACE 2011), which is more than any other federal agency. Riparian buffers can support a wide range of wildlife, which increases recreational opportunities for birders and other wildlife observation.

- ***Positive Public Relations*** – The general public places high value on activities that protect natural resources and provide wildlife conservation benefits. Providing increased riparian area along shorelines and stream banks on USACE reservoirs would potentially provide increased recreational areas as well as suitable habitat for riparian-dependent wildlife, including endangered species.

- ***Wildlife Habitat*** – Riparian areas with sufficient vegetation to provide for the life histories of wildlife can provide an ideal habitat for many species of birds, mammals, reptiles, amphibians, and other wildlife taxa. Functioning riparian areas provide shade for aquatic species such as fish and macroinvertebrates, and they can also serve as movement corridors for wildlife migration.

- ***Noise Reduction*** – Vegetated buffers can act as sound barriers.

Endangered Species Act and Habitat Restoration Opportunities. The U.S. Army Engineer Research and Development Center Environmental Laboratory (ERDC/EL) has embarked on a new initiative under the Dredging Operations and Environmental Research (DOER) Program called the Threatened and Endangered Species Team (TEST). Under this initiative, ERDC-EL is developing strategies to: assess threatened, endangered, and at-risk species on a national scale, determine how to prioritize focus on these species, develop potential solutions that will improve

operational flexibility, reduce future costs, reduce adverse impacts on missions, and improve species conservation (including, in some cases, species recovery). TEST utilizes strategic collaborations internally (i.e., Headquarters, Division, District, and ERDC programs and field staff and scientists), and externally (i.e., other agencies and stakeholders) to identify issues and develop and implement cost-effective and efficient approaches and solutions. TEST is the platform for initiating and coordinating Endangered Species Act Section 7(a)(1) efforts, particularly Conservation Planning, which Major General Peabody recently elevated as a USACE priority (Hartfield et al. 2015). Section 7(a)(1) includes Conservation Planning, within USACE and with coordination among other federal agencies, to address both federally listed species and at-risk species.

Contribution of Riparian Areas to Sensitive Species. Riparian areas provide essential habitat for many bird species (Fischer 1999). Avian density and species richness in riparian areas have been estimated at almost double the amount found in upland areas, particularly in the southwestern U.S. In the southwest, approximately 50 percent of bird species nest in riparian areas, and the percentage increases to 82 percent in northern Colorado. As a focus of the proposed riparian rehabilitation efforts in the southwest, three bird species federally listed in the Endangered Species Act (ESA) (Figure 2) will be addressed: the southwestern Willow Flycatcher (*Empidonax traillii (*Audubon, 1828)), Least Bell's Vireo (*Vireo bellii* (Audubon 1844)), and the Western Yellow-billed Cuckoo (*Coccyzus americanus* (Linnaeus, 1758)). Guilfolye (2001) provided a good overview of stressors impacting western populations of these bird species.

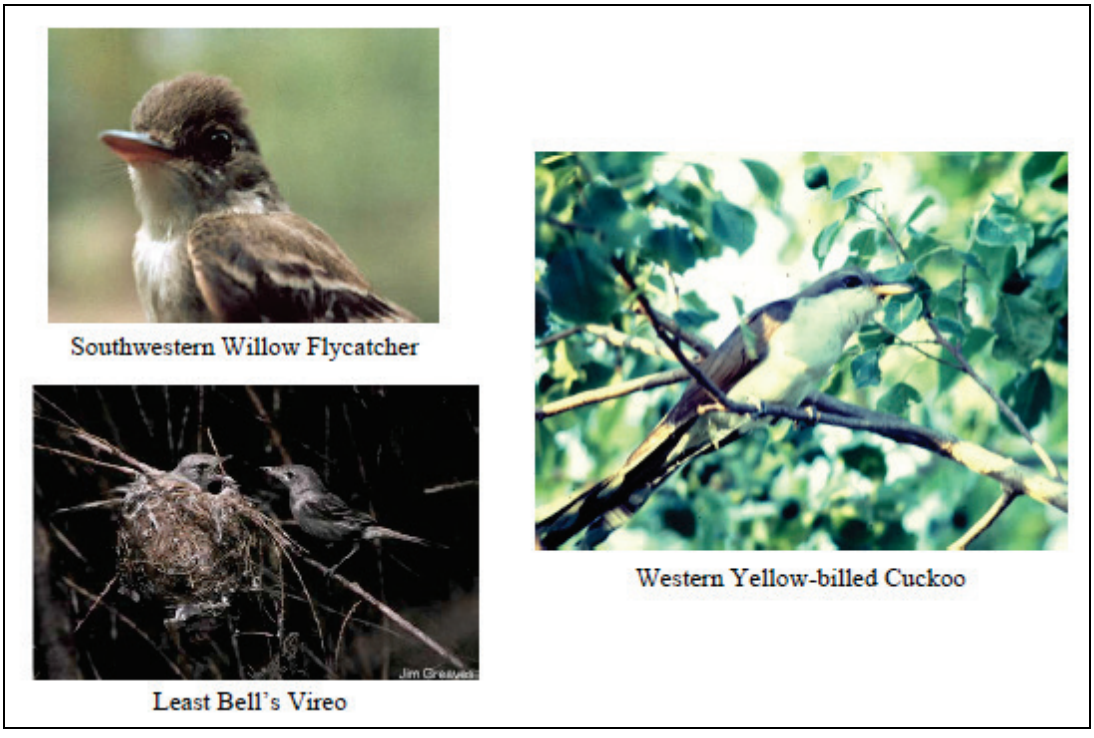

Figure 2. Bird Species of Concern (from Guilfoyle 2001).

Southwestern Willow Flycatcher. The Willow Flycatcher is a migratory species that nests in shrubby areas along riparian corridors (Sedgwick 2000). It is insectivorous, catching most of its

prey while in flight. Habitat destruction from livestock grazing impacts Willow Flycatcher habitat because it potentially reduces habitat quality and destroys nests, as well as hydrologic modifications that reduce regeneration of native riparian habitat. It is considered common in the northeastern U.S., but is federally listed as endangered in New Mexico, Arizona, and California. There has been concern that the spread of tamarisk (*Tamarix* sp., also known as salt cedar), an invasive, shrub-like tree, has degraded habitat by displacing vegetation that the Willow Flycatcher needs for nesting, although more recent studies indicate flycatchers often use this species for nesting sites with little impact on nest success and recruitment. Brown-headed Cowbirds (*Molothrus ater* Boddaert 1783), which lays eggs in the nests of flycatchers and other birds, also impact the Willow Flycatcher. The host species nurture the Cowbird young, decreasing the survival of their own young.

Least Bell's Vireo. The Least Bell's Vireo is a small, migratory, insectivorous bird (Brown 2010) that breeds in the central and southwestern U.S. and winters in southern Mexico and Baja California. Preferred habitat is upland scrub and riparian areas. Least Bell's Vireo uses a wide variety of shrubs and small trees for habitat and nest construction. It prefers dense, brushy areas, particularly associated with early succession (Brown 2010). Availability of surface water is an important consideration for Bell's Vireo habitat.

The Least Bell's Vireo was listed as endangered in 1986 in California and remains listed to date. Land uses and habitat alteration, fragmentation, and loss are key reasons for the decline of the vireo. Invasive plant species in riparian habitat, particularly the giant reed (*Arundo donax* L, an invasive species from Asia), has significant negative impacts to habitat. Brown-headed Cowbirds significantly impact the Least Bell's Vireo, and the effect of parasitism is exacerbated due to the loss of habitat by land uses and conversion. Furthermore, many of the common land use changes affecting succession have actually favored the cowbirds over the vireo.

Habitat restoration is a key aspect in conservation of the Least Bell's Vireo. Protection of existing habitat and restoration of degraded habitat, including removal of giant cane, and creation of new habitat are considered critical for recovery. Bell's Vireo rapidly colonizes newly established habitats, so properly designed and implemented restoration projects have high probability for success.

Western Yellow-billed Cuckoo. The yellow-billed cuckoo is a widely distributed bird in North America and is actually considered secure in portions of its range in the eastern U.S. as well as parts of Texas. However, its numbers have declined significantly in other parts of North America (Hughes 2015). It has already been extirpated from the Pacific Northwest (e.g., British Columbia, Oregon, and Washington), and the Western Yellow-billed Cuckoo Distinct Population Segment, found in Arizona, New Mexico, and California, recently was federally listed as Threatened. Most remaining western birds are primarily found in isolated patches of riparian habitat. Yellow-billed Cuckoos typically prefer riparian areas along watercourses, particularly in the western United States. They prefer low, dense, scrubby vegetation and can use several different types of shrubs and trees as nesting sites (Hughes 2015).

The Yellow-billed Cuckoo is especially sensitive to pesticides and metals (Hughes 2015). Sub-lethal effects include behavioral impacts that result in lower survivability. Higher level impacts include effects on eggs, which can result in viability failure. Habitat degradation and fragmentation

has impacted the Yellow-billed Cuckoo and resulted in loss of habitat connectivity. It has unusual breeding habits, which may make it more susceptible to habitat changes. Nesting success in tamarisk appears to decrease, and the species suffers significantly from Brown-head Cowbird nest parasitism (Brodhead et al. 2007). They require relatively large (>20 hectares) contiguous patches of riparian habitat with multiple vegetation layers for nesting, and will nest in a variety of successional stages as long as habitat conditions are suitable.

DESIGNING RIPARIAN AREAS FOR RUNOFF PROTECTION AND HABITAT FOR THREATENED/ENDANGERED BIRDS: As part of the TEST strategy, the ERDC-EL will initiate planning for an FY17 riparian restoration demonstration project in the southwestern U.S. Objectives for this demonstration are to exhibit feasibility of establishing vegetated riparian areas along either reservoir shorelines or reservoir tributaries that provide both water quality protection/improvement and habitat for regionally sensitive riparian-dependent species. The focus will be on developing a strategy for the conservation of the three TES riparian bird species in areas of the Southwest where USACE has management authority. In the past 10 years, ESA-compliance for Southwestern Willow Flycatcher, Least Bell's Vireo, and the recently federally listed Distinct Population Segment of Yellow-billed Cuckoo in riparian areas (and reservoir habitats) of the Southwest has resulted in the agency's highest ESA-related costs (for birds), outside of those expended for Interior Least Terns and Great Plains Piping Plovers on regulated rivers with jeopardy Biological Opinions.

The strategy will identify specific opportunities to develop ESA Section 7(a)(1) plans that use all of the Corps' management authorities to minimize negative effects and, wherever possible, raise the baseline for these three listed species. This follows on a Corps-wide memo from Major General Peabody, and a similar memo from the U.S. Fish and Wildlife Services (USFWS), to use 7(a)(1) more broadly and within agency missions and authorities, since it allows for the Corps to have greater control over species/management interactions (and possibly, lower costs) than the terms and conditions that typically result from Section 7(a)(2) consultations. Increasing the use of 7(a)(1) is a major objective of the TEST program.

Riparian areas often are intentionally restored, created, or enhanced using bioengineering techniques and native plantings to restore multiple functions to the ecosystem (Fischer et al. 1999, Fischer 2003). Listed below are some guidelines that are being considered for riparian areas for both runoff protection and habitat for endangered bird species.

Minimum dimensions. Fischer and Fischenich (2000) have several tables that summarize studies on effective dimensions for buffer strips and corridors. The overwhelming majority of scientific investigations on riparian widths typically focus on designs for controlling non-point source pollution such as sediment and nutrients. To achieve water quality goals, riparian buffer widths can be relatively narrow when compared to many ecological functions, typically on the order of 30 to 50m wide, and some studies indicate that buffers as narrow as 4m can be effective for nutrient and bacterial control (Mayer et al. 2006). However, for wildlife habitat, most studies suggest significantly wider riparian areas are needed (Fischer et al. 1999, Fischer 2000). Studies consistently show that wider riparian areas support a wider diversity of species and abundance of individuals. The majority of studies investigating width come from forested landscapes in the eastern and northern portions of North America, with relatively less guidance in the southwestern

U.S. As a general rule, riparian widths of ≥100 m should support the establishment and maintenance of neotropical migratory bird populations (which the target species are). However, riparian areas in the Southwest tend to be much narrower. The habitat requirements of the target species will be explored during rehabilitation planning efforts. Furthermore, many species require corridors for movement and dispersal. Thus, it may be necessary to provide a series of interlinked riparian habitats to obtain the highest benefit possible.

VEGETATION

Appropriate vegetation. Riparian vegetation typically includes grasses, shrubs, and trees. Each vegetation type has its own advantages (see Table 6 in Fischer and Fischenich 2000). For example, grasses are excellent for nutrient uptake and sediment control, but are only average for protecting shorelines from bank erosion. Shrubs are best for bank erosion control, but are not particularly good for contaminant control. Relatively small riparian zones consist predominantly of one vegetation type. However for larger zones that support habitat, diversity is generally better, and it should ideally contain all three vegetation types. Again, life-history needs of target species will be explored, as well as site-specific, non-point, source pollution issues, during any rehabilitation planning.

Planting. Planting in arid and semi-arid climates typically found in the western and southwestern U.S. can be challenging due to nutrient deficiencies and low water availability (Fischer 2003, Fischer 2004). The use of soil amendments and/or irrigation may be necessary to establish plants. Commercial fertilizers can often help with nutrient issues. Compost is a good fertilizer that also provides water-holding capacity and improves soil structure – and it tends to be relatively inexpensive. Perlite is a common material used to improve water-holding capacity. Superabsorbent polymers can also be good materials to hold water in soils (Fischer and Fischenich 2000) and have been tested in arid and semi-arid environments, but their overall benefits are questionable (Fischer 2004, Figure 3). Another new material is a biopolymer produced by the bacteria *Rhizobium tropici*. ERDC-EL has patented a means of producing this biopolymer and synthesizing it into a dry powder that can be easily transported and applied (Newman et al. 2010). Research has shown the effectiveness of this biopolymer in stimulating plant growth in several environments (Larson et al. 2012). Soil amendments often are essential to establish plants, but may not be needed over time. Once the plants are established, plant litter and animal droppings can provide nutrients and roots, and plant litter can serve to hold water in the soils.

Irrigation systems can also be valuable for establishing riparian vegetation (Fischenich 2000). Such systems typically need to be used for one to two initial growing systems. Drip and sprinkler systems are typically sufficient and are water efficient. After that, the root systems are generally developed to the point that they help retain water, and irrigation systems can be removed.

Figure 3. Superabsorbent polymers used in studies for arid studies.

The edges of the riparian areas can be susceptible to erosion, even if it is planted, particularly if there is a sharp drop off from the planted area into the water, as can be the case with reservoir shorelines. Wave action can work below rooted areas, allowing for significant erosion. In these cases, engineered structures can provide protection. Engineered structures can be prepared from geotextiles or even large woody debris. Geotextile mats can hold newly planted vegetation in place until it grows enough to establish good root systems (Allan and Clark 1999). Geotextile rolls can be used as breakwaters, and they can also support planted vegetation (Allan and Clark 1999). Woody materials can be used to create inexpensive, yet effective, breakwaters, and they have been explored for recovery of near shore riparian zones after devastating storms (Channell et al. 2009)

One challenge of maintaining riparian vegetation is that reservoirs frequently have significant fluctuations in water levels (Allen and Klimas 1986) based on a variety of factors, including hydropower, recreation, and water supply needs. Drawdowns between 30 to 85m are not uncommon. This can significantly impact rooted vegetation that is potentially reliant on reservoir water in the root zone. Low-pool conditions also can provide extensive mudflats where tributaries flow into reservoirs. Plants capable of withstanding these changing conditions should be considered during rehabilitation efforts. Alternatively, some pool levels can inundate riparian vegetation. It is paramount that any rehabilitation efforts be completed in consultation with the USFWS under the ESA 7(a)(1) framework, and that safeguards be in place to prevent project operational influences if unavoidable impacts (e.g., flooding) occur to listed species in rehabilitated areas (see below).

Management of nuisance species. Giant Reed is a particularly problematic, non-native invasive plant species (Bell 1997). It grows very quickly, out competes native plants, has few natural enemies outside of its native range, and does not provide a food source or nesting habitat for birds and other species. During rehabilitation efforts, care should be taken to prevent its introduction, and sites should be monitored so that it can be quickly removed if discovered.

Tamarisk is another non-native invasive species of concern in southwestern riparian areas. Although some bird species will nest in tamarisk, care should be taken to determine if some level of control is necessary in areas where it is prevalent (van Riper et al. 2008). If tamarisk is established, replacing it with native vegetation may not always provide intended benefits to bird

communities (Shanahan et al. 2011). A monitoring program should be implemented post-planting to assess the level of non-native invasions, as well as a plan to control above a specified threshold.

Water. Riparian rehabilitation efforts in the southwestern U.S. should also consider the need for water for plant establishment and survival. Because of altered hydrology associated with many rivers, groundwater is frequently diminished, making it difficult to maintain riparian vegetation communities (Fischer 2003). Furthermore, many bird species prefer water in proximity to nesting habitat.

Management of Parasitic Species. The Brown-headed Cowbird has a deleterious effect on all the potential focal bird species in this study, and particularly with the Least Bell's Vireo. Any necessary management steps will be explored, such as trapping, to reduce Brown-headed Cowbird impacts on target species.

Management of Succession. Because of species-specific habitat requirements, some adaptive management may be implemented to track habitat conditions of rehabilitated areas over time. In particular, Least Bell's Vireo prefers early successional habitat. Thus habitat management through thinning or other management techniques may be necessary for maintenance.

Monitoring. A monitoring and adaptive management plan will be established to determine the effectiveness of rehabilitation efforts for both water quality and wildlife habitat. Fry et al. (1994) outlines an approach that can be used to assess quality of riparian areas in arid environments based on vegetation, species present, etc. In addition, the use of a common, indicator species can be useful. Kirkpatrick et al. (2009) indicated that the presence of Black Phoebe, a native but fairly common bird, can be a good indicator if habitat favors more sensitive species.

Implementation to limit problematic impacts. Restoring and maintaining habitat for endangered species is a significant contribution to the USACE environmental restoration mission. However, it is necessary to ensure that rehabilitation activities that might encourage use by federally listed species do not conflict with USACE mission areas. Historically, federally listed species have posed problems to USACE by reducing operational flexibility and incurring significant costs. The authors propose that these potential conflicts can be minimized by careful planning, including:

- Choosing areas for riparian rehabilitation that are not near mission critical sites, such as near hydropower equipment, navigation locks and structures, shipping zones, water intakes, etc.

- Partnering with other state and federal agencies, and non-governmental organizations to assist with long-term operation and maintenance of these sites.

- Working directly with the USFWS such that rehabilitation efforts on reservoirs are included in a larger ESA Section 7(a)(1) planning effort (Hartfield et al. 2015).

BENEFITS TO USACE: Benefits of planning and implementing a riparian restoration project in the SPD include, (a) demonstrating the feasibility and effectiveness of planting cost-effective riparian buffer strips that have high return on investment for USACE; (b) improving reservoir

water quality by reducing non-point source pollutant (likely sediments) input; and (c) developing collaborations with partners for creating habitat of importance to regionally sensitive riparian-dependent species, including federally listed species.

SUMMARY: The ERDC-EL is planning at least one reservoir riparian rehabilitation in the southwestern U.S. as a means to demonstrate capabilities for improving water quality and creating/enhancing sensitive species habitat. This effort will involve the Water Operations Technical Support (WOTS) program (for water quality benefits) and the ERDC-EL TEST initiative (for endangered species conservation planning). This demonstration should contribute to the planning of other similar projects where water quality and/or endangered species habitats are focal objectives.

ADDITIONAL INFORMATION: This technical note was prepared by the following ERDC-EL researchers Victor F. Medina, Ph.D., P.E., Research Engineer, Richard Fischer, Ph.D., Research Wildlife Biologist, and Carlos Ruiz, Ph.D., Research Engineer. The study was conducted as an activity of the WOTS program. For information on the WOTS program, please contact the Program Manager, Dr. Pat Deliman at *Patrick.N.Deliman@usace.army.mil*. This technical note should be cited as follows:

> Medina, V.F., R. Fischer, and C. Ruiz. 2016. *Riparian buffers for runoff control and sensitive species habitat at U.S. Army Corps of Engineers dams and waterways*. ERDC WQTN-16-1. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

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